Exam I
12 October 2004

• This exam contains 6 pages of questions – confirm this once you begin
• An abbreviated periodic table can be found on the last page
• You will have 80 minutes
• No calculators or models are permitted
• Read all questions carefully – answer the question that is asked!
• Illegible or indecipherable answers may not receive potential partial credit
• Good luck!

1. (9 pts) Draw equilibrium arrows that indicate the preferred position of the following acid-base reactions and circle the approximate $K_{eq}$ for each of these as written.

   a) $\text{CH}_3\text{O} + \text{NaOCH}_3 \rightleftharpoons \text{CH}_3\text{O} + \text{HOCH}_3$ 
      $K_{eq} =$ $10^{-8}$ $10^{-4}$ $10^4$ $10^8$

   b) $\text{Na} + \text{H}_2\text{O} \rightleftharpoons \text{Na} + \text{HOH}$ 
      $K_{eq} =$ $10^{-7}$ $10^{-3}$ $10^3$ $10^7$

   c) $\text{H}_2\text{O} \rightleftharpoons \text{Na} + \text{HOH}$ 
      $K_{eq} =$ $10^{-15}$ $10^{-10}$ $10^{10}$ $10^{15}$
2. (21 pts) Provide the structure of the major organic product or products expected from each of the following reactions. Write "NR" if no reaction. Indicate stereochemistry where applicable.
3. (8 pts) As head of production at The Claisen Persuasion Chemical Co. your job is to keep costs down by making sure the research chemists on your staff make sensible chemical decisions. The newest addition to your team, Al Dole, has proposed the following reactions. Comment on Al’s proposals briefly describing what problems, if any, will arise.

a) 
\[ \text{CH}_3\text{CO}_2\text{H} + \text{PhCO}_2\text{H} \xrightarrow{1) \text{CH}_3\text{ONa, CH}_3\text{OH}} \text{CH}_3\text{OCH}_3 \xrightarrow{2) \text{H}_3\text{O}^+} \]

b) 
\[ \text{CH}_3\text{CO}_2\text{H} \xrightarrow{1) \text{CH}_3\text{ONa, CH}_3\text{OH}} \text{PhCO}_2\text{H} \xrightarrow{2) \text{H}_3\text{O}^+} \]

4. (7 pts) Provide the missing reagents for the following transformation. If more than one step is required then be sure to number each step.
5. (18 pts) Clearly circle the correct answer for the following questions. There is only one correct answer for each; no credit will be given if more than one answer is circled for each question.

a) Which of the following is not a Michael acceptor?

\[ \text{O} \quad \text{C} \quad \text{CN} \]

b) A dialkylcuprate would participate in \( \text{______} \) (1,2 or 1,4) addition with compound A, whereas an alkyllithium reagent would prefer to add in a \( \text{______} \) (1,2 or 1,4) manner.

\[ \text{A} \quad \text{O} \]

c) Which of the following is the best candidate for a crossed aldol reaction with acetone?

\[ \text{H} \quad \text{O} \quad \text{H} \quad \text{O} \]

d) Which of the following represents the tautomer of 3-pentanone?

\[ \text{O} \quad \text{H} \quad \text{O} \quad \text{O} \quad \text{H} \]

e) Which of the following is by definition an intramolecular condensation reaction?

aldol Hell-Volhard-Zelinsky Claisen Dieckmann

f) Identify the most acidic compound from among the following:

\[ \text{O} \quad \text{O} \quad \text{O} \]

g) The equilibrium constant (\( K_{eq} \)) for the following equation is approximately:

\[ \text{C} \quad \text{O} \quad \text{ONa} \quad \text{K}_{eq} = 10^8 \quad 10^4 \quad 10^0 \quad 10^{-4} \quad 10^{-8} \]

h) Treating the compound shown below with \( \text{D}_3\text{O}^+ \) will result in what number of H/D exchanges?

\[ \text{# of H/D exchanges = } \]

i) Which of the following will undergo the haloform reaction (\( \text{NaOH}, \text{excess I}_2 \))?

\[ \text{O} \quad \text{O} \quad \text{O} \]
6. (10 pts) Provide a complete and detailed mechanism for the following reaction. Be sure to clearly show arrows, lone pairs, and formal charges. You need only arrive at the circled structure.

\[
\begin{align*}
\text{O} & \quad \text{H}_3\text{O}^+ \quad (\text{workup}) \\
\text{Na^+} & \text{O} \\
\text{O} & \quad \text{O} \quad \text{Na}^+ \\
\end{align*}
\]

7. (12 pts) Determine the starting organic compound(s) used in the following reactions.

\[
\begin{align*}
\text{H}_2\text{O} & \quad \text{NaOH} \\
\text{H}_2\text{O} & \quad \text{NaOH} \\
\end{align*}
\]
8. (6 pts) Circle the major product expected from the acid-promoted chlorination of 2-methylcyclohexanone. Briefly (~ 2 - 3 sentences and using structures as needed) explain your choice.

\[
\text{Keton} \xrightarrow{\text{Cl}_2, \text{H}_3\text{O}^+} \text{A} + \text{B}
\]

9. (9 pts) Provide a complete and detailed mechanism for the formation of the major product you selected in question #8. (You will not be penalized in this problem for having selected the wrong product in question #8.) Be sure to clearly show arrows, lone pairs, and formal charges.